

SPACE WEATHERING IN HOUSTON: A ROLE FOR THE EXPERIMENTAL IMPACT LABORATORY AT JSC: M.J. Cintala¹ (Mark.J.Cintala@nasa.gov), L.P. Keller¹, R. Christoffersen², and F. Hörz³. ¹Code XI3, ARES NASA JSC ²Jacobs/JETS Contract, Code XI2, NASA JSC, ³LZ Technology, all in Houston, TX 77058.

Introduction: The effective investigation of space weathering demands an interdisciplinary approach that is at least as diversified as any other in planetary science. Because it is a macroscopic process affecting all bodies in the solar system, impact and its resulting shock effects must be given detailed attention in this regard. Direct observation of the effects of impact is most readily done for the Moon, but it still remains difficult for other bodies in the solar system. Analyses of meteorites and precious returned samples provide clues for space weathering on asteroids, but many deductions arising from those studies must still be considered circumstantial. Theoretical work is also indispensable, but it can only go as far as the sometimes meager data allow. Experimentation, however, can permit near real-time study of myriad processes that could contribute to space weathering. This contribution describes some of the capabilities of the Johnson Space Center's Experimental Impact Laboratory (EIL) and how they might help in understanding the space-weathering process.

Laboratory Overview: The EIL comprises three separate, distinct accelerators: a 5.56-mm (bore diameter) light-gas gun (LGG), a 40-mm flat-plate accelerator (FPA), and a vertical gun that can use a variety of barrels, depending on an experiment's requirements. The LGG and FPA are mounted horizontally. Each of the three is equipped with a vacuum system and an impact chamber that can support an almost unlimited variety of target configurations. All sequencing and real-time data collection are performed through PCs with LabVIEW software.

Target vaporization appears to be a critically important requirement for some aspects of nanophase Fe (npFe⁰) generation [1]. The shock stresses required for wholesale vaporization of most relevant geological materials [2], unfortunately, are beyond the capability of almost all laboratory accelerators on the planet. The LGG and FPA, however, are easily capable of inducing impact melting, and even the vertical gun has generated impact melts in fragmental gabbro targets [3]. Liquid-nitrogen-based systems are available for cooling targets in both the FPA and vertical-gun to temperatures below -100°C in vacuum, and a similar capability is planned for the LGG. Brief descriptions of the three accelerators follow.

The Light-Gas Gun: Projectiles ranging from around 3 mm to 1 μm in diameter can be launched with the LGG to speeds on the order of 7 km s⁻¹. All

projectiles are confined in a four-piece sabot, and the smaller ones are "shotgunned" to assure multiple impacts on the target. A sample-containment assembly is under construction that will allow retention and subsequent collection of almost all shocked target material from a given impact. It will include mounts for aerogel coupons that will decelerate and trap high-speed ejecta, if desired.

The Flat-Plate Accelerator: High stresses are obtained with the FPA through a shock-reverberation process [4]: the sample material is encased in a solid-metal container, and the impact of a flat "flyer plate" onto the surface of the container generates a planar shock front that passes through the metal and into the target. It then reflects off the backing metal and through the sample again. This continues until the decompression front passes through the flyer plate and enters the sample holder; each passage of the shock through the sample raises the stress level. Provided the flyer plate is sufficiently thick, the final stress will equal the metal-on-metal shock pressure. The shocked sample can then be recovered for any of a wide range of analyses, including petrographic, e-beam, calorimetric, spectral, etc. Because the peak-shock stress is attained in a stepwise manner (*i.e.*, through the reverberations), the entropy increase suffered by the sample is typically less than that acquired by passage of a single shock of the same peak stress level. Therefore, the result of an FPA experiment must be treated as the minimum that would be induced by an impact generating that peak shock stress. This method was used, for example, to investigate the shock melting of an ordinary chondrite [5].

The Vertical Gun: Like the FPA, the vertical gun uses simple gunpowder as a propellant; its speed ceiling is thus around 2.8 km s⁻¹. Nevertheless, it is easily capable of six to eight experiments per day (depending on the time required for target setup). This, along with its ability to launch projectiles over a wide range of diameters, compositions, and masses, makes it a very useful tool for studies such as those involving laboratory-generated "regoliths" [3,6].

References: [1] Keller and McKay (1993) *Science* **261**, 1305. [2] Ahrens and O'Keefe (1972) *The Moon* **4**, 214. [3] Hörz *et al.* (1985) *PLPSC 15* in *JGR* **89**, C183. [4] Gibbons and Ahrens (1971) *JGR* **76**, 5489. [5] Hörz *et al.* (2005) *MAPS* **40**, 1329. [6] Cintala *et al.* (2015), in preparation.